



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

reason to believe that the archaic culture gave way to the higher civilization of the Maya at about the time of Christ. It had doubtless lasted a very long time since the deposits of this period are very thick. But once implanted in Venezuela the archaic culture, free from the pressure of higher arts, might have maintained itself till the coming of the Spaniards. There is evidence, however, of considerable pressure of population by wild tribes from the south and the little that is known of Venezuelan ethnology is not in full accord with the archaeology.

Beyond Venezuela we may be permitted to indicate the probable course of ancient empire. There is little doubt in the mind of the writer that the archaic culture—standing everywhere for sedentary agricultural communities, skilful in making pottery and textiles—was once laid down across northern South America and that the remarkable pottery of Marajo, at the mouth of the Amazon will prove to be a distant but congenital relative of the ware from the lowermost stratum of human handicraft in the Valley of Mexico.

The full data resulting from this exploration together with that obtained by further field studies will appear in the *Anthropological Papers* of the American Museum of Natural History.

NOTE ON THE PHOSPHORESCENCE OF URANYL SALTS

By Edward L. Nichols

DEPARTMENT OF PHYSICS, CORNELL UNIVERSITY

Received by the Academy, May 9, 1916

Phosphorescence is commonly regarded simply as the after effect of fluorescence, the emission spectrum immediately after the close of excitation being identical with that immediately before excitation ceases. This has hitherto been only an assumption, since it is thinkable that the process which prepares a substance for phosphorescence might produce emission during excitation differing from that which constitutes phosphorescence and which together with the latter would be present during fluorescence. It is also thinkable although unlikely that the phosphorescence might contain some components requiring a measurable time for development and observable only after an appreciable interval.

This is a matter which it would be very difficult to settle in the cases of phosphorescence hitherto studied because the spectrum of fluorescence and phosphorescence consists of broad bands or complexes of overlapping bands and almost the only criterion of identity is that of color.

It is true that the color of fluorescence is frequently different from that observed during the phosphorescent period but that is rightly as-

cribed to the existence of two or more bands differing greatly in their rate of decay. This is indeed a phenomenon, common to all the phosphorescent sulphides, which has been extensively studied by Lenard¹ and others and recently by a different method by the present writer.²

The uranyl salts on account of their remarkable spectra afford an unusual opportunity for the determination of this question but while the fluorescence of these substances has been examined in great detail little or no attention has been given to their phosphorescence.

A new form of phosphoroscope, the synchrono-phosphoroscope, recently described by the author³ of this paper is well adapted for the observation of these fleeting phenomena, which have a duration of only a few thousandths of a second, and the study of the phosphorescence of a typical uranyl salt, to be described in the present paper, was one of the first uses to which this instrument was put.

The method, briefly outlined, is as follows. The substance, enclosed in a flat tube of glass about 8 cm. long and 2 cm. wide, is viewed through

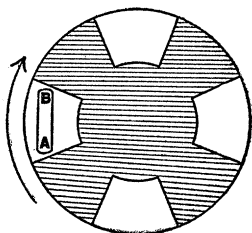


FIG. 1.

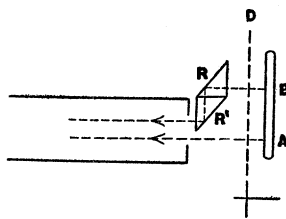


FIG. 2.

the rapidly revolving sectored disk of the synchrono-phosphoroscope. It is mounted vertically with its axis at right angles to the radius of the disk as shown in figure 1.

It is uniformly excited by zinc sparks 120 times a second while hidden by the closed sectors and is visible for $1/240$ of a second during the passage of each of the intervening open sectors.

A phosphorescent substance of slow decay appears under these circumstances to be equally bright from top to bottom but if one of the uranyl salts, such as the double uranyl-ammonio sulphate, which was the substance selected for detailed study, be used, it appears a very bright green at the bottom of the tube shading off to bare visibility at the top.

The rate of decay of this substance, and of the other uranyl salts is so rapid that the upper end of the tube, which is seen at the intensity which corresponds approximately to the instant 0.003 second after excitation, has only a small fraction of the brightness of the lower end which is viewed about 0.0005 second after excitation.

The great advantage to be gained from the study of these substances is due to the well known fact that in their spectra the usual broad band of fluorescence or phosphorescence is resolved into a group of seven or more bands which do not overlap and that at low temperatures (-150° to -180°) these are further resolved into complexes of narrow line-like bands often well separated from one another. The particular salt mentioned above was selected because at low temperature each group is unusually well resolved into at least seven such distinct bands. It should therefore be possible by comparing the spectrum during excitation with that immediately after, to detect changes affecting the individual components; something which is impossible in the case of the broad-banded spectra hitherto examined.

For the purpose of such comparisons a pair of right angled prisms was mounted before the slit of a Hilger spectroscope as shown in figure 2.

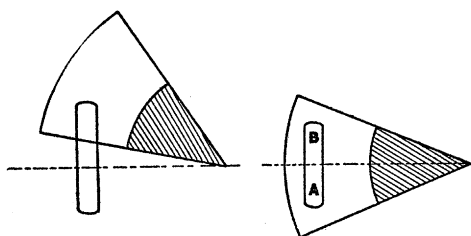


FIG. 3a.

FIG. 3b.

Light from the lower end of the tube *A* enters the lower half of the slit. That from the upper end *B* after two total reflections enters the upper half of the slit and we have two spectra one above the other, coinciding throughout, as to wave length, but separated by a dark line

formed by the lower edge of the second prism (*R'*).

To compare fluorescence with phosphorescence the sectorized disk was shifted upon its shaft until the lower end of the tube was viewed during excitation, the upper end immediately after (fig. 3 a). To compare the phosphorescence spectrum at an earlier and later stage the disk was so set that its position at the moment of excitation was as shown in fig. 3 b. By means of the reflecting prisms at the slit of the spectroscope, already described, the spectrum of the light emitted from region *A* was compared with that at *B* in each case. At $+20^{\circ}$ the banded spectra were found to be identical in every respect, except in brightness; and the same was true at low temperatures where it was possible to inspect each of the numerous line-like bands individually.

Of the seven homologous series distinguishable in the fluorescence spectrum all were present in the phosphorescent light, unshifted as to position and not perceptibly enhanced or diminished in relative brightness.

The comparison was less satisfactory as regards minor details in the

case of the early and late stages of phosphorescence, some of the fainter bands being invisible but changes such as might be looked for, i.e., those due to the greater persistence of certain series, could scarcely have escaped notice. The significance of these observations is two-fold:

On the one hand we find that for the only examples of luminescence which admit of such detailed inspection, *the spectrum of phosphorescence is identical with that of fluorescence* and since there are no indications to the contrary in the case of other classes of substances thus far studied it is probable that the above statement will apply to all phosphorescent materials.

On the other hand we find that in spite of its great complexity, the luminescence spectrum of a uranyl salt is to be regarded as a unit, all its components decaying at the same rate after the cessation of excitation.

With this instrument the change of intensity of phosphorescence with the time may likewise be readily determined and as no one appears to have studied the uranyl salts in this respect, it seemed of interest to obtain the curve of decay of one of the salts under observation, i.e., the uranyl-ammonio sulphate.

To this end a simple form of photometer previously used in a study of the phosphorescence of Kunzite⁴ was mounted in front of the sectored disk. A lateral strip of the phosphorescent salt 1 cm. wide was excited by sparks from a single spark gap between zinc terminals and measurements of the brightness were made at various times after the close of excitation. The necessary conditions were attained by shifting the disk successively through small angles so as to vary the interval between excitation and observation. The time could be estimated with sufficient accuracy by noting the instantaneous positions of the disk for each adjustment, as given by the strictly synchronous illumination due to the spark.

The arrangement of the apparatus is shown in figure 4 in which *P* is the phosphorescent surface, *DD* the sectored disk, *L. B.* the Lummer-Brodhun cube of the photometer, *E* the eye-piece, *S* a color screen and matte translucent plate, *C* the comparison lamp which travelled along the track of an optical bench. The cross at *Z* indicates the position of the spark gap.

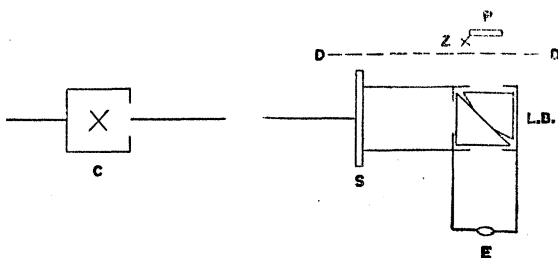


FIG. 4.

TABLE I.

T	I	$1/\sqrt{I}$
0.000479	59.49	0.130
0.000637	27.78	0.190
0.000856	16.02	0.250
0.000949	12.62	0.281
0.00110	9.80	0.319
0.00146	5.03	0.446
0.00170	2.03	0.702
0.00193	0.971	1.014
0.00212	0.610	1.280
0.00247	0.296	1.836
0.00287	0.159*	2.524*

* These values are probably somewhat less accurate than the other data given in this table.

results are likewise plotted in the customary manner with $1/\sqrt{I}$ as ordinates (curve *DEF*) and this brings out an unusual characteristic hitherto unobserved so far as the writer is aware in studies of phosphorescence except in the solitary case of paraffine recorded by E. H. Kennard.⁵ It is usual to find two processes of phosphorescence succeeding one another and represented by the two straight arms of the curve *DE* and *FG* but in all the numerous cases hitherto described, excepting that of paraffine just noted where a very slight upward trend was found, the later process (*FG*) is indicated by a curve of lesser slope. In the case of this uranyl salt, however, *FG* trends very sharply upward showing a greatly accelerated decay. Whether this peculiarity is confined to these salts or is a common property of phosphorescence of exceed-

In Table I relative intensities *I*, the reciprocals $1/\sqrt{I}$ and times *T* after excitation are given. Figure 5 shows the relations between *I* and *T*, and $1/\sqrt{I}$ and *T* respectively in the usual manner.

As appears from the table and curve *ABC* figure 5 this substance exhibits a remarkably rapid decay, falling in the interval between 0.0005 second after close of excitation and 0.003 second to less than three-thousandths of its intensity at the beginning of that interval. To show the degree of accuracy with which the lower intensities were observed the portion of the curve (*BC*) is reproduced with ordinates magnified ten times (*B'C'*). The

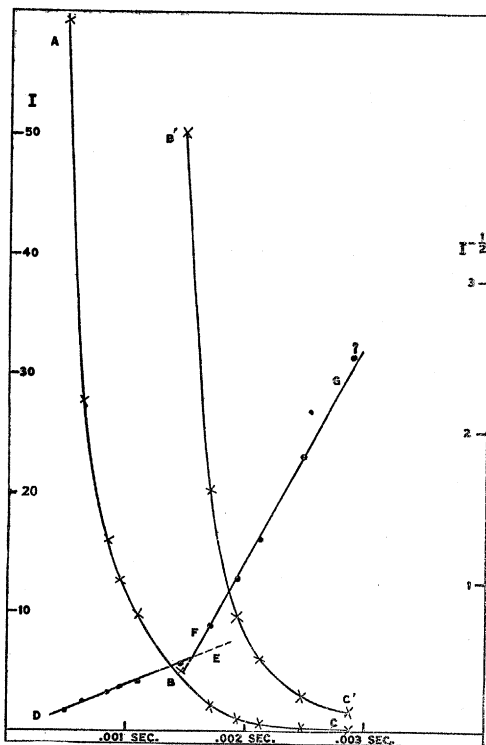


FIG. 5.

ingly rapid rates of attenuation, remains to be determined. With the help of Dr. H. L. Howes, to whose assistance throughout this investigation the author is greatly indebted, this question is now under investigation.

¹ Lenard, *Ann. Physik*, ser. 4, 31, 641 (1910).

² E. L. Nichols, Paper presented before the Amer. Philos. Soc., April, 1916.

³ Nichols and Howes, Paper presented before the Amer. Physic. Soc., April, 1916.

⁴ Nichols and Howes, *Physic. Rev.*, ser. 2, 4, 19 (1914).

⁵ Kennard, *Physic. Rev.*, ser. 2, 4, 278.

THE PYRANOMETER: AN INSTRUMENT FOR MEASURING SKY RADIATION

By C. G. Abbot and L. B. Aldrich

ASTROPHYSICAL OBSERVATORY, SMITHSONIAN INSTITUTION

Read before the Academy, April 18, 1916. Received April 30, 1916

This instrument, as its name (from the Greek $\pi\upsilon\rho$, fire, $\acute{\alpha}\nu\acute{\alpha}$, up, $\mu\acute{\epsilon}\tau\rho\nu$, a measure) indicates, is intended to measure the heat equivalent of radiation received from or going out toward the complete hemisphere above the plane of the measuring surface. We have devised two satisfactory types of the instrument, both derived in principle from the electrical compensation radiation instruments of the late K. Ångström. The full description of the instruments and tests of them will be found in a paper now being published in the *Smithsonian Institution Miscellaneous Collections*. The instruments are adapted to measure direct solar radiation, the total radiation of the sun and sky combined, that of the sky alone, and nocturnal radiation. It is possible to employ screens of selective transmission and thus to limit the measurements to selected spectrum regions. The instruments are of primary standard type, but have been compared with the standardized pyrheliometers of the Smithsonian Institution and found accordant. No auxiliary apparatus other than that employed with the Ångström pyrheliometer is required, and the observations are easy to make.

The simpler form of pyranometer comprises a single blackened manganin strip, 3 mm. wide, 6 mm. long, placed centrally in the plane of the upper surface of a nickel-plated copper disk 75 mm. in diameter. Copper blocks insulated from the rest of the disk, but continuous with it in surface, serve to connect the insulated manganin strip with an electric heating current of adjustable strength. A sensitive thermo-electric couple fastened by means of thin waxed paper to the rear surface of the manganin strip, and embedded at the other end in a recess of the copper disk serves to indicate changes of temperature of the strip. Concen-